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IMAGE DATABASE SYSTEM FOR JAPANESE KOSODE GARMENTS ON JAPAN GIGABIT NETWORKS

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Abstract

A new image database system of Japanese KOSODE garments supplied from The National Museum of Japanese History was constructed for the effective distribution and display of high definition and super high definition still images, with the aid of the image retrieval. The new system is characterized by the automatic generation of the index images used for the image matching in the image retrieval, and the use of JPEG2000 for handling super-high definition still images. The automatic index image generation reduced the generation time from 35 min. to 110 sec. The system performance was actually tested over IPv4/IPv6 on the Japan Gigabit Networks.

Keywords: image directory, image server, high definition still images, IPv4/IPv6, index generation.

1. Introduction

Internet has become an important tool for business and industry this decade of years [1]. Communication technologies are becoming spread out of the realm of voice communications to the realm of image and video communications [2]-[4]. On the other hand, from the viewpoint of business and industry, high-definition photographic images are required for exchanging pictorial information. For handling high-definition images, information storage having a capacity of tens of gigabytes needs to be used in computer communications. This trend of technology enables the computer to handle high-definition images [5]. In addition, high definition television plasma display panels (HDTV PDP's) and high-definition liquid crystal displays (LCD's), which have been put into practical use for displaying high-definition images these one-two years, can also be used for computer communications. So, the image database systems are considered practical for communications in business and industry in these one-two years, especially in Japan and the United States.

The multimedia database system contains storage having a capacity much more larger than that which has been realized before. So, the concept of the image directory, which has been proposed by K. SUZUKI et al., is strongly required to be employed in the database system configuration [6]. In accordance with the previous studies of K. SUZUKI et al., the use of images for the retrieval is much more effective

than the use of keywords [7]-[9]. The retrieval of a digital image referring to a typical index image is in most cases easier than that which is carried out referring to the keywords specifying a typical digital index image [7]-[10]. Operators who are familiar with digital images can perform the image retrieval referring to these index images easily. This type of image retrieval is independent of the languages used in the retrieval system, user's age, user's culture, and user's knowledge [6]. This means the rate of matching between the index and desired key images will be high enough to practically use the image retrieval in an actual database system.

However, index images to be compared with a sketched image used as a key in the image retrieval had manually been generated so that they could be cataloged into the directory server for further image retrieval [9]. Due to the cost-performance tradeoff, the manual index image generation prevents the image retrieval to be used in a variety of image database systems.

In the image database system operated utilizing the image directory in the image retrieval, the processing time needed to manually generate an index image was too much long, i.e., 35 minutes. This processing time can be shortened to a great extent by the DSP technology in which the background of the image to be used as the index is set uniform utilizing the threshold below which image components are automatically cut.

The concept of image database systems, which have been constructed by K. SUZUKI et al. [6], can be extended to construct a new image database system storing Japanese KOSODE garments.

This paper describes, as well as the index image generation, the basic configuration of the image database system constructed utilizing the Applet and Servlet Applications, operated with the aid of Apache® and Tomcat®. The performance was greatly improved in the image retrieval using a sketched image drawn by the customer, and in its practical applications to an academic experimental system for Japanese KOSODE garments stored in The National Museum of Japanese History, Sakura, Chiba, Japan.

2. Image Database System

2.1. System Outlines

Fig. 1 shows the system outline of the image database system. The basic configuration of the image database system is designed on the basis of the configuration described in literature [6]. The image database system is constructed with a directory server, an image server, and man-machine interface (MMI) devices. The directory server consists of directory control and directory information. Directory control in the directory server has an Applet for tools, interfacing with the MMI control, served by Apache®, and the Stamp, Sketch, and Image Retrieval Servlets controlled by Tomcat®. Directory information in the directory server has images of stamps, logging sketches drawn by the customers, index images, and images of

samples and directions to high and super-high definition still images in the image servers.

Directory control in the image server contains Apache® serving for taking out the designated still images, responding to the address specified by the customer.

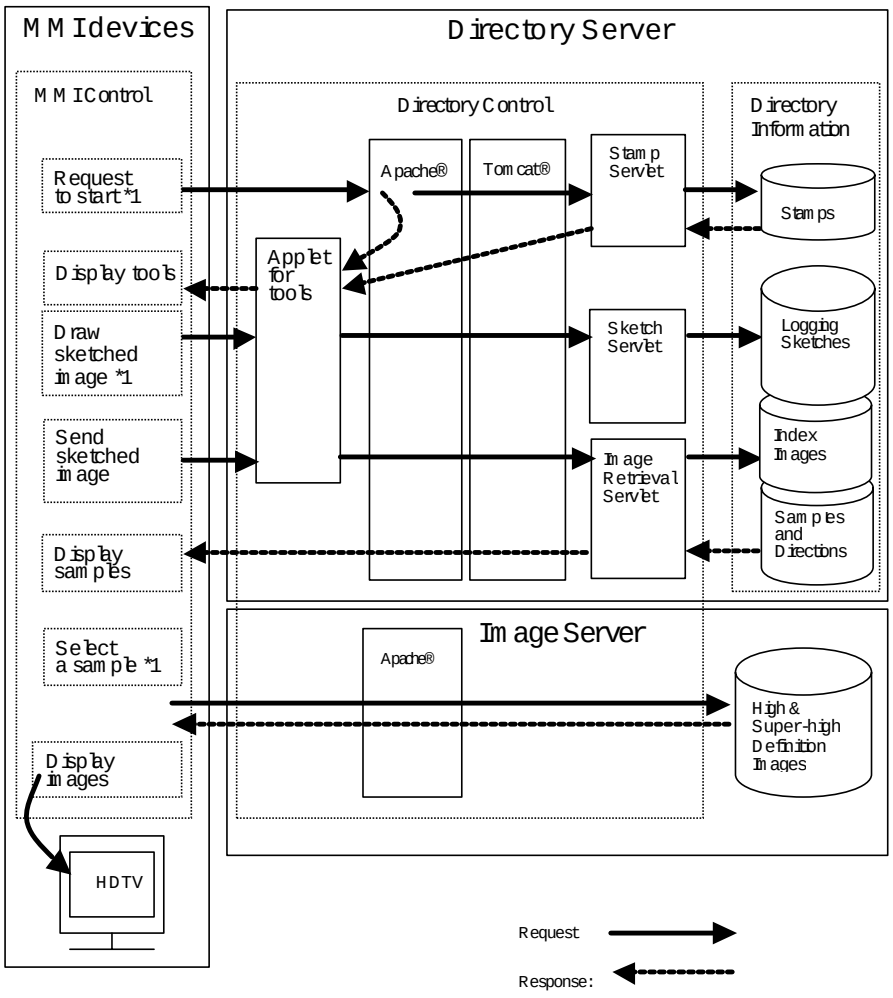

Fig. 1. System configuration of the image database system

2.2. Directory Server

2.2.1. Directory Control

Directory control consists of an Applet for tools, served by Apache®, and three types of Servlets, served by Tomcat®; i.e., a Stamp Servlet to pick up stamps from the directory information, a Sketch Servlet to log the sketched images drawn by the customers into the directory information, and an Image Retrieval Servlet to perform the image retrieval, referring to the sample images and directions to the high and super-high definition images in the image server.

The customer issues a request for the image retrieval to the Applet for tools through the Apache®. (See a broken line in *Fig. 1*.) In accordance with the request issued to the Applet for tools, the Applet for tools controls the Stamp Servlet to pick up stamps through the Apache® and Tomcat®. The Applet for tools generates the sketching tools, based on the stamps sent from the Stamp Servlet. Then, the sketching tools are displayed on the MMI devices.

The customer draws a sketched image and sends it to the Applet for tools in the directory server. The Applet for tools sends the sketched image received from the MMI control both to the Sketch Servlet for logging the sketched images and to the Image Retrieval Servlet to perform the image retrieval referring to the sample images. Resulting from the image retrieval, both the sample images and directions are demonstrated on the MMI devices. The Apache® and Tomcat® are needed to transfer the requests and responses between the MMI control and Servlets in the directory server.

Fig. 2 shows the functions contained in the respective Servlet Applications. Since the Stamp Servlet, Sketch Servlet, and Image Retrieval Servlet are installed in the directory control of *Fig. 1*, each Servlet consists of a Web service function, a database connection function, and an operation function set.

The Web service function interfaces with the MMI control in the MMI device through Apache® and Tomcat®. The Web service function is constructed with the user identification module to identify an event from the MMI control, HTML transfer module to transfer an HTML file to the MMI control, and HTML generation module to generate an HTML file.

The database connection function interfaces with directory information. The database connection function is constructed with the SQL generation module to generate the SQL instructions set and the SQL execution module to execute the SQL instructions.

The operation function set consists of Stamp function, Sketch function, and Image Retrieval function.

The Stamp function is installed in the Stamp Servlet to pick up stamps from the directory information. The Sketch function is installed in the Sketch Servlet to send the sketched images to the directory information for logging purposes. The Image Retrieval function is installed in the Image Retrieval Servlet to retrieve the resembling images referring to the sketched image received from the MMI control.

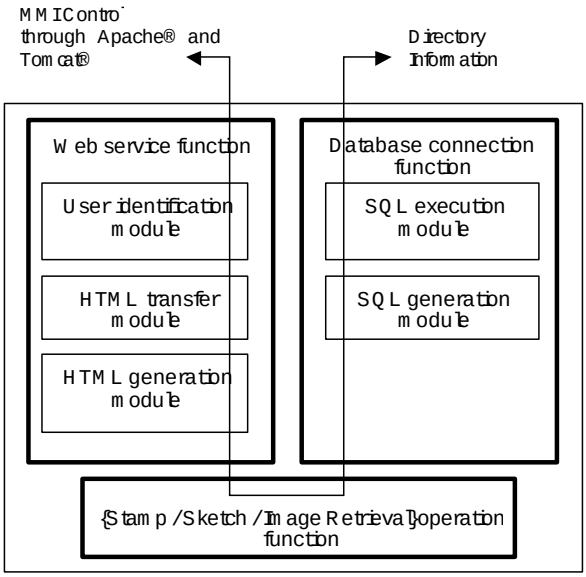

Fig. 2. Functions in the respective Servlet Applications.

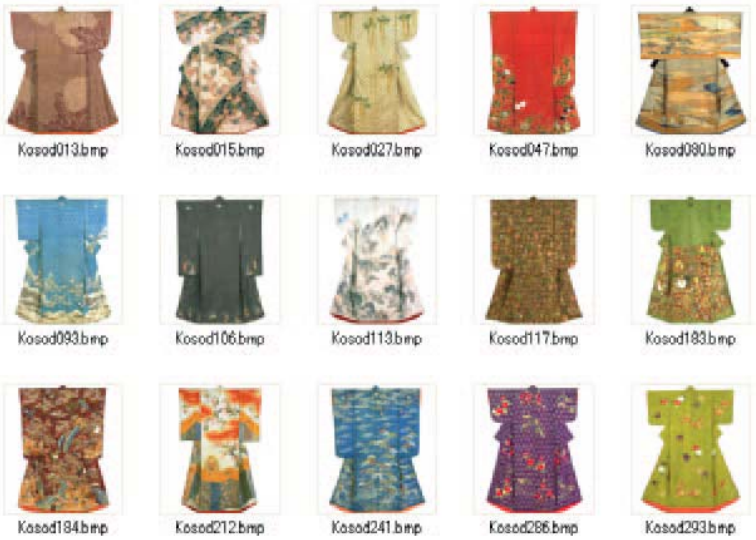

Fig. 3. Sample images assigned to the super-high definition images..

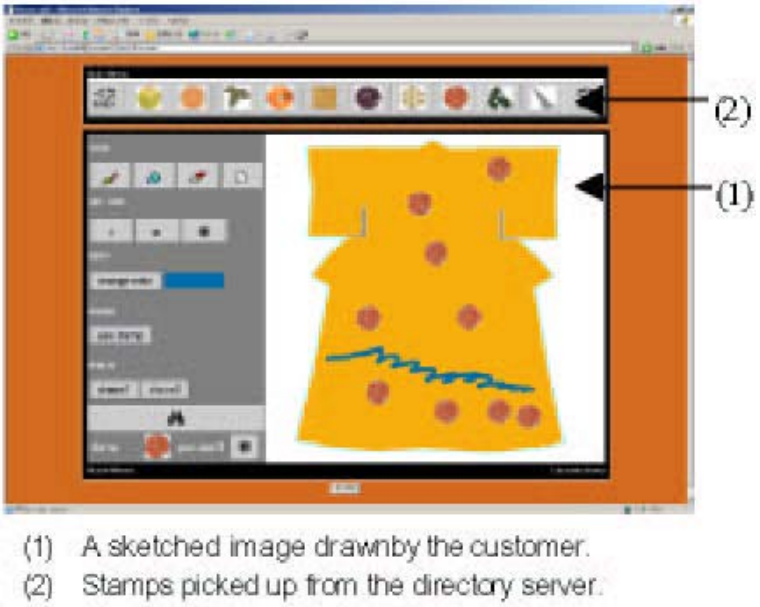

Fig. 4. Tools for drawing a sketch.

2.2.2. Directory Information

Directory information stores four types of images, i.e., stamps, logging sketches, index images, and samples and directions. The stamps are used as the tools for displaying typical textile patterns on the MMI devices for use in easily drawing the sketched images. Logging sketches indicate the sketched images drawn by the customer on the MMI devices so that the sketched images are logged in the directory information. The index images indicate the indexes used for the image retrieval. The samples and directions constitute typical sample images and addresses of the high and super-high definition still images in the image server, respectively. *Fig. 3* shows the sample images assigned to the super-high definition images.

2.3. Image Server

The image server stores high and super-high definition still images, made from photographs taken to obtain high definition digital contents. The Apache® picks up the designated still image specified by the customer, and provides it to the MMI devices.

Fig. 5. Samples and directions, shown on the MMI devices.

Fig. 6. High definition still image displayed on HDTV PDP.

Fig. 7. Super-high definition still image displayed on HDTV PDP.

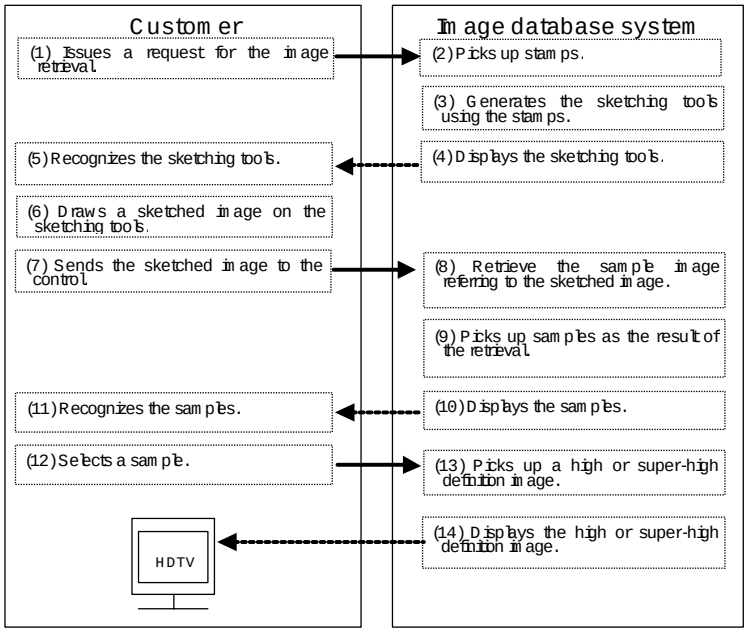

Fig. 8. System operation of the image database system

2.4. MMI Devices

2.4.1. MMI Control

On the MMI devices, the customer starts requesting the image retrieval, utilizing the Applet for tools designed to be used for Java® applications. The web browser is needed to satisfactorily perform the IO operations on the networks utilizing the MMI control.

2.4.2. HDTV Display

An HDTV PDP is used as part of the MMI devices to demonstrate a high or super-high definition still image. The HDTV PDP having an active area size of 36 inches displays analog RGB image signals obtained by DAC from the digital images stored in the image server. The HDTV PDP is suitable for demonstrating high and super-high definition still images since both colour reproduction and resolution are satisfactory over the large display area. Other characteristics of the HDTV PDP, including the dynamic ranges of brightness, gamma, and viewing angle, are suitable for displaying a variety of images.

2.4.3. Demonstration of Images on MMI Devices

Fig. 4 shows a frame of tools for drawing a sketched image, which was assembled utilizing the Applet for tools. The stamps which have appeared in the frame of *Fig. 4* are kept stored in the Stamps area of directory information in the directory server. (See *Fig. 1*.)

The Stamp Servlet of *Fig. 1* takes the stamps out of the directory information in the directory server, and sends them to the Applet for tools. (See the dotted line in *Fig. 1*.) Each sketched image drawn by the customer on the frame of tools is stored in the Logging Sketches area in the directory information.

The Image Retrieval Servlet compares the sketched image with the index images kept stored in the directory information. The samples and directions are picked up and sent to the MMI control as the result of the comparison.

Fig. 5 shows the samples and directions for the images resembling the sketched image specified by the frame of *Fig. 4*, which have been obtained as the result of the image retrieval. The directions below the respective samples indicate the addresses of the corresponding high or super high definition still images.

When the customer specifies a high definition still image, the designated image is sent from the image server to the MMI control, and then it is demonstrated on the HDTV PDP as shown in *Fig. 6*. One of these super-high definition images processed by JPEG2000 can be displayed on HDTV PDP as shown in *Fig. 7*.

3. Operation

Fig. 8 shows the system operation of the image database system. The image database system starts operating when the customer issues a request for the image retrieval on the MMI control. Control picks up stamps, and generates the sketching tools using the stamps (See (1) through (4) in *Fig. 8*). The frame of sketching tools displayed on the MMI devices is shown in *Fig. 4*. The customer recognizes the sketching tools, and draws a sketched image on the frame of sketching tools (see *Fig. 4*(1)). When the sketched image is completely drawn (see *Fig. 4*(2)), the sketched image is sent to the control (see (5) through (7) in *Fig. 8*). Control retrieves the sample image referring to the sketched image sent by the customer, and picks up samples as the result of the retrieval. Control displays the samples on the MMI devices, which are shown in *Fig. 5* (see (8) through (10) in *Fig. 8*). The customer recognizes the displayed samples, and selects a sample (see (11) and (12) in *Fig. 8*). Control picks up a high or super-high definition image based on the selected sample, and displays it on the HDTV PDP. The high and super-high definition images are respectively shown in *Fig. 6* and *Fig. 7* (see (13) and (14) in *Fig. 8*).

4. Index Image Generation

Fig. 9 shows the procedures of index image generation using DSP and directory server applications. In *Fig. 9*, operating procedures (a) through (f) are as follows:

(a) Converts to intensity data (Y) the original high definition still image consisting of three primary colours RGB.

(b) Generates the contour of the object, recognized as the boundary between the object and background.

(c) Dissects the object area of the original still image from the background, based on the contour generated by DSP.

Inverts the background picked up by the above process.

Deletes margins at the top and bottom of the image frame. Deletes blank areas on the left and right.

(d) Reduces the index image frame to the normal size of 128 by 128 pixels for establishing the easy-to-operate interface.

(e) Catalogs the generated index image to the image database.

(f) Attaches the index image to the original still image for use as operator's assistance.

Procedures (a) through (c) are executed using the DSP applications, and (d) through (f) are executed using the directory server applications.

4.1. DSP Applications and Directory Server Applications

Table 1 summarizes the specifications for the DSP board, NVDK64®of ATEME. The DSP applications had been installed in the DSP board, and the DSP board had been mounted on the PC/AT. The directory server applications had been installed in the Workstation, i.e., GP400 of Fujitsu. The contours were generated using the spatial edge filters realized by DSP applications. The details are given in the followings.

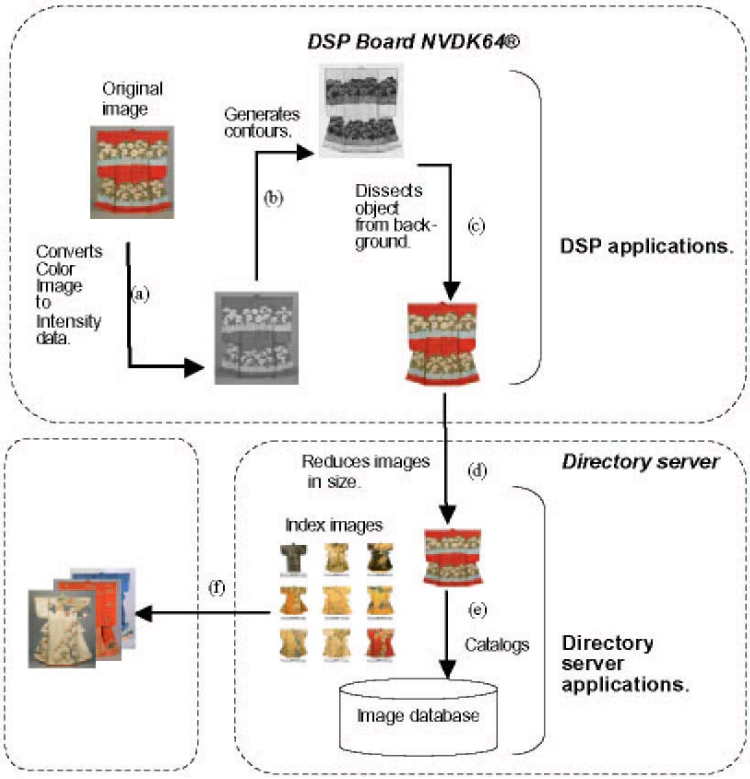

Fig. 9. Index image generation and cataloging.

4.2. Contour Generation

Among the well known spatial edge filters, i.e., Prewitt, Sobel, and Laplacian, the Sobel filter was chosen, based on the results of experimental tests, to generate the contours of the object. Original images of Kosode garments, supplied from the National Museum of Japanese History as samples, were of 1,926 by 2,467

Table 1. Specifications for NVDK64®

Elements	Specs.
DSP	TMS320C6416 operating at 600 MHz
External Memory	256MB in 64 bit units
External Memory	8MB in 16 bit units
Interface	PCI
PCI interface data rate	33MHz in 33bit units
PC/AT used together with DSP	IBM Netvista®
	Pentium 4; To be connected to PCI Bus.

pixels, and these samples were reduced to the images of 512 by 512 pixels in the experimental study for use to generate the index images.

A preliminary test was carried out to check if the samples of Kosode garments were completely matched to their reduced images to be used as the index images. All the 231 samples were confirmed to be matched to the original images prepared by manual index generation in a size of 512 by 512 pixels. In accordance with the schematic configuration of the high-definition image database system, the index image should not be of high definition image because it can be used only for the communication controls in the image retrieval. Colour images of 512 by 512 pixels were first converted to the corresponding monochrome images in order to generate their contours using the Sobel filter. Grayscales of intensity data on the monochrome image were distributed over the wide range of 0 to 255, while they were collected to the grayscale range of above 200 after the Sobel filter was applied to the monochrome image. So, the threshold to determine the contours was set at a grayscale level of 200 in accordance with this test.

The Sobel filter was the best among the others because the change of the number of pixels in terms of the grayscale change was abrupt in accordance with the preliminary test, and so the dissection of the object image from the background was the easiest among the above mentioned spatial filters.

Fig. 10 shows a contour pattern of the monochrome image of Kosode garment used as a sample. The contour pattern was generated by setting the threshold at a level of 200.

4.3. Contour Pattern Enhancement

The contours generated using the Sobel filter are complete if the object area enclosed within the contour is closed from the background area. In other words, the line of the contour may partly be cut if the contour has weekly appeared. If the background area is scanned while the threshold is kept set at a finite level of grayscales, leaks can occur in the object area. If the scanned area leaks from the background into

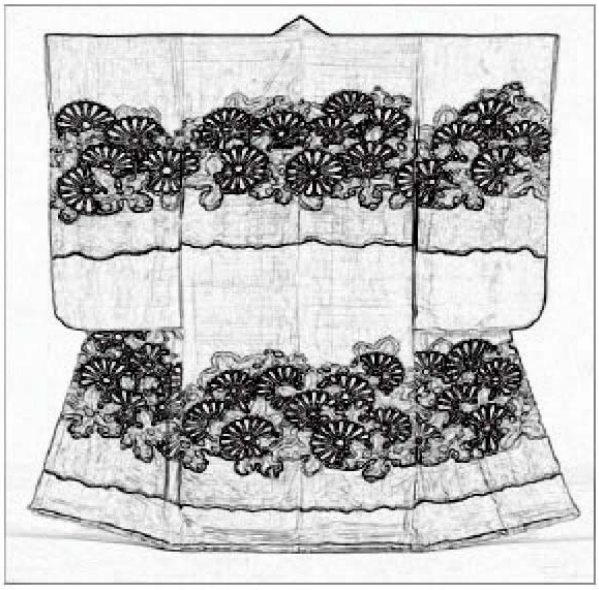

Fig. 10. Contour pattern of the monochrome image of KOSODE garment used.

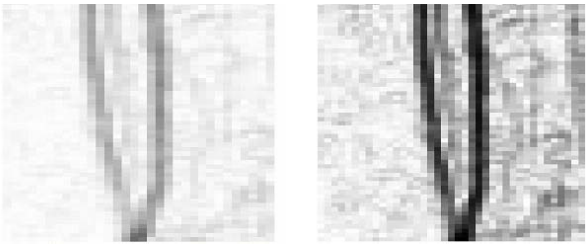

Fig. 11. Contour pattern of the monochrome image of KOSODE garment used.

the object and the object area, the object area will partly be set at the level of the background, which causes an error in the determination of the object area.

The following methods were employed to enhance the edge patterns of the contours so that the contours of the object could be closed completely.

1. Control enhances the magnitudes of the inverted contour patterns by 1.5.
2. Control corrects the gamma of the inverted contour patterns by 2.5.

The contours were actually compensated by amplifying the magnitudes of the inverted contour patterns and then by correcting the gamma. *Fig. 11* shows the extended view of the result of the compensation. Data in *Fig.* **??**(b) was obtained from the contour of *Fig. 11(a)* when the magnitude of the contour at the Sobel

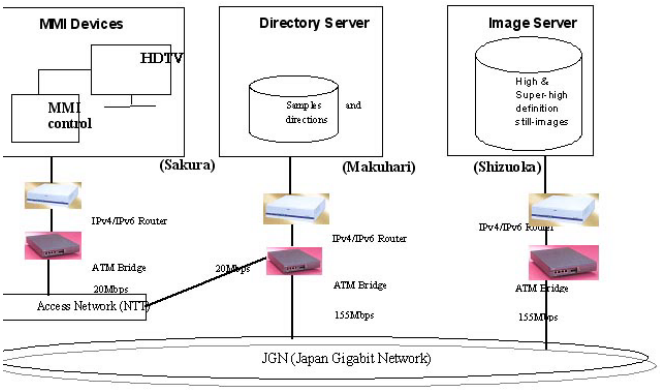

Fig. 12. Contour pattern of the monochrome image of KOSODE garment used.

filter output was amplified by a factor of 1.5 and when the gamma of the magnified contour was set at a factor of 2.5.

4.4. Verification on Database System

With the index images generated in accordance with the proposed method, the processing time for preparing the index image was reduced to 110 seconds including the interfacing operations while it was 35 minutes in manual operations. Among 231 pieces of Kosode garments, each of 230 images obtained as the result of the image retrieval had appeared in the first place while the remaining one in the second place. This indicates the precision of 99.6 %.

5. Prototype of the System

5.1. System Implementation on JGN (Japan Gigabit Networks)

The image database system consists of a directory server, an image server, and MMI devices open for the customers, which are connected together through the Japan Gigabit Networks (JGN). The system architecture is shown in *Fig. 12*. The directory server was set up at Makuhari Gigabit Research Center, Makuhari, Japan.

The image server was set up at the University of Shizuoka, Shizuoka, Japan. The MMI devices were set up at The National Museum of Japanese History, Sakura, Japan.

The MMI devices consist of MMI control and an HDTV PDP. The web browser was utilized to establish the user terminal platform in the MMI control. When control designates a high or super-high definition still image in the image server, the HDTV PDP can display the designated image utilizing the MMI control in the MMI devices. The MMI control interfaces with the directory server, and lets the image server transmit image data to the HDTV PDP.

The Sun Workstation was used for the directory server since the directory server had to be of high performance, and two PC's were respectively used for the image server and the MMI control in the MMI devices. Each of these devices was connected to the JGN through the IPv6/IPv4 router and ATM MA155SX/4E bridge. After the MMI devices were moved from Sakura to Makuhari in Jan. 2002, a running test was started to check if the system was applicable to practical facilities. The running test was continued for two years, and terminated in Jan. 2004. No trouble was found in the image retrieval during the running test.

5.2. High Definition Still Images

High and super-high definition still images were supplied from The National Museum of Japanese History, Sakura, Chiba, Japan. The source images of 2048 by 2048 and 18000 by 15000 pixels were prepared from 231 pieces of Kosode garments, which were installed in the image server, each having a grayscale of 256 (8bits) in three primary colours. These contents were satisfactorily demonstrated on the HDTV PDP.

6. Conclusions

The concept of the directory server cooperated with the image servers and MMI devices were developed for the distribution of high definition contents. High definition contents consisting of high and super-high definition still images of Japanese KOSODE garments were satisfactorily sent from the image server, and distributed over the networks to the MMI devices under the MMI control operations. Performance of this image database system, which was tested on the IPv4/IPv6 environment through the Japan Gigabit Networks (JGN), was confirmed satisfactorily. The test continued for two years form Jan. 2002 to Jan. 2004.

The directory control in the directory server was effective to transfer control information between the MMI control in the MMI devices and the directory information in the directory server. The image retrieval responding to the customer's request was successful. The index images in the directory information were automatically generated using the DSP applications. The Resulting from the processing

to automatically generate the index images with the DSP applications, the accuracy of indexing was 99.6%.

Since the system can be built worldwide without any boundaries among nations and the Java® applications used for the user terminals can be downloaded from the directory server in any place, this system is considered to be useful for displaying super-high definition still images, as well as high definition still images, in academic and business applications in the world.

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